PHILIPS

Electronic components and materials

MAY 17 1982

Laboratory report

Elcoma applications laboratories

For your personal information

number : NTI8201 date : 03-02-1982

title : a UHF RF stage with the MOST tetrode BF980.

author : R.C.Thuis

The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of :

N.V. Philips' Gloeilampenfabrieken
Electronic Components and Materials Division
Eindhoven - The Netherlands

Electronic components and materials

PHILIPS

laboratory report

The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of: N.V. Philips' Gloeilampenfabrieken - Eindhoven - The Netherlands
Product Division Electronic Components and Materials

number : NTI8201 date : 03-02-1982

title : a UHF RF stage with the MOST tetrode BF980.

author : R.C.Thuis

Information presented in this report is based on pilot studies in our laboratories. It is presented in good faith but N.V. Philips' Gloeilampenfabrieken assumes no liability for any consequences of its use. Its presentation does not imply a licence under any patent, trademark, or copyright.

N.V. PHILIPS SEMICONDUCTORS APPLICATION LABORATORY
NIJMEGEN – THE NETHERLANDS

REPORT No: NTI 8201
PROJECT No:

AUTHOR: R.C. Thuis

DATE: 03-02-1982.

TITLE

A UHF RF STAGE WITH THE MOST TETRODE BF980

SUMMARY

In Fig. 1S the circuit diagram of the RF stage is given.
It shows that gate 1 of the MOST is coupled to the antenna tuned circuit via the decoupling capacitor Cm_1 of the varicap diode D1 and the coupling coil Lm_1.
The drain has been coupled to the primary of the bandpass-filter in a more usual way by means of Lm_2 and Cm_2.
Both matching networks are necessary for the following reasons:

a) Because of the rather high input capacitance of the MOST tetrode "Cis", a direct coupling of gate 1 to the antenna tuned circuit would cause an unacceptable decrease of its tuning range.
b) Both input and output damping of the MOST, increase strongly with frequency. On the other hand, the damping of the tuned circuits decreases with frequency. By means of the mentioned impedance transforming networks, an almost constant bandwidth and mismatch loss is achieved.

The impedance transforming networks on the input and output of the MOST are designed in such a manner that their parasitic resonance frequencies amount to about 900 and 450MHz resp.

Advice Patents Dept. d.d: 29-04-82	X AV	GV		B		BL
Decision MAMO d.d: 19-04-82	X AV	GV	EI	B		BL
DATE: 1 APR. 1982	MAMO:					

PHILIPS

The great difference between these frequencies is necessary to prevent a parasitic bandpass of the RF stage.
It reduces also the risk for parasitic oscillations.
Decreasing the costprice, in the RF stage the lechersystems are replaced by coils.
This measure demands for a complete redesign of the bandpass filter, which appeared to be rather difficult.
Therefore the design of the bandpass filter and also some measures to prevent parasitic oscillations are detailed.

Measured results.

Freq. (MHz)	Tuning Voltage (Volt)	Noise fig. (dB)	Transd. gain (dB)	Gain red. (dB)	3dB band width (MHz)	VSWR (m.b.) nom	VSWR (m.b.) at.max
470	1.7	3.3	13.8	48	24	1.8	2.8
600	7.7	3.5	11.0	40	23	1.4	2.6
730	13.5	3.9	10.2	41	24	1.4	3.4
860	25.1	4.2	10.0	44	19	1.4	3.1

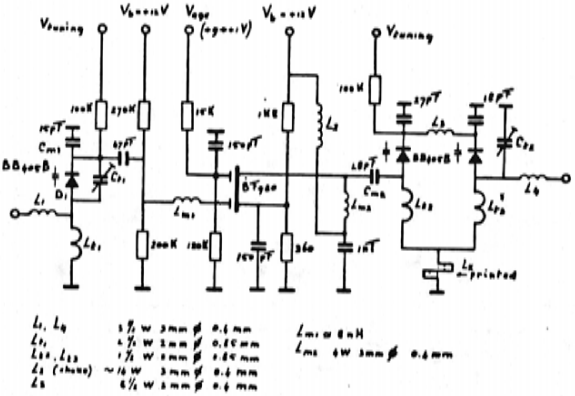


Fig.1S

The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of: N.V. Philips' Gloeilampenfabrieken - Eindhoven - The Netherlands Product Division Electronic Components and Materials.

Electronic components and materials

Information presented in this report is based on pilot studies in our laboratories. It is presented in good faith but N.V. Philips' Gloeilampenfabrieken assumes no liability for any consequences of its use. Its presentation does not imply a licence under any patent, trademark or copyright.

N.V. PHILIPS SEMICONDUCTORS APPLICATION LABORATORY
NIJMEGEN – THE NETHERLANDS

REPORT No: NTI 8201
PROJECT No:

AUTHOR: R.C. Thuis

DATE: 03-02-1982.

TITLE

A UHF RF STAGE WITH THE MOST TETRODE BF980

ABSTRACT.

In almost all the conventional UHF tuners, the RF transistor has been coupled to the antenna via a high-pass input filter.
In that case the in-band interfering signals are also present at the RF transistor, causing a decrease of the signal-handling capability of the RF stage.
This can be improved by means of a MOST tetrode in the RF stage, which is coupled to the antenna by means of a tuned circuit.
This provides extra selectivity and with that an improvement of the signal-handling capability.
In the circuit, problems concerning the impedance matching of the MOST to the tuned circuits and the influence of the MOST on the tuning range has been solved.
The tuned circuits are realized by means of ordinary coils which delivered some difficulties at the design of the pandpass filter.
Therefore much attention has been paid on this subject.
Also an analyse of possible instability sources is given.
According to the knowledge gathered in this report a UHF RF stage has been built.
The performance with the application of the BF980 is very good.

	Advice Patents Dept. d.d:	AV	GV		B		BL
	Decision MAMO d.d:	AV	GV	EI	B		BL
	DATE:	MAMO:					

PHILIPS

Contents:

1. Introduction.
2. The RF bandpass filter.
3. The input circuit of the RF stage.
   3.1. Parallel matching network.
   3.2. Series matching network.
4. The tracking of the RF stage.
5. Measures for designing a stable RF stage.
   5.1. Simplified equivalent circuit of a MOST tetrode.
   5.2. The influence of the print lay-out on the stability.
   5.3. Instability due to the inductance in the decoupling connection of gate 2.
6. Practical lay-out of the printed board.
   6.1. The coupling of the bandpass filter.
   6.2. Design methods for a positive coupling.
   6.2.1. The inductive T coupling via Lk.
   6.2.2. The inductive TT coupling via L3.
   6.3. Design methods for a negative coupling.
   6.3.1. The indirect inductive coupling.
   6.3.2. The capacitive TT coupling.
7. Measurements.
8. Conclusion.
9. References.

The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of: N.V. Philips' Gloeilampenfabrieken - Eindhoven - The Netherlands Product Division Electronic Components and Materials.

Electronic components and materials

Information presented in this report is based on pilot studies in our laboratories. It is presented in good faith but N.V. Philips' Gloeilampenfabrieken assumes no liability for any consequences of its use. Its presentation does not imply a licence under any patent, trademark or copyright.

PHILIPS

1. INTRODUCTION.

Due to the fact that both the input and output damping of a MOST tetrode do strongly increase with frequency, it is impossible to apply the device in a UHF circuit without any special measures. Therefore, transforming networks are used on the gate and drain of the MOST providing a good impedance match to the tuned circuits. This measure results in an almost frequency independent transducer gain, bandwidth and noise factor.

2. THE RF BANDPASS FILTER.

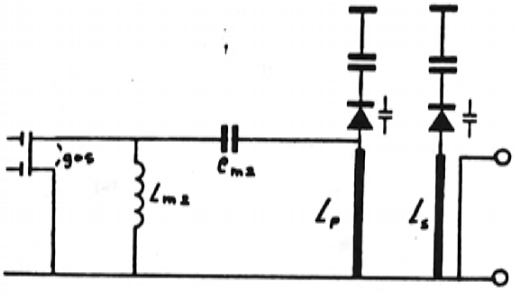


Fig. 2.

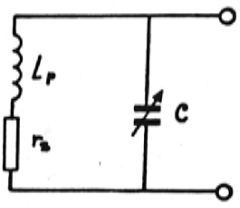
As shown in Fig. 2 the MOST is not connected directly in parallel to the primary of the bandpass-filter, but via an impedance transforming network Lm_2-Cm_2.
This is necessary to achieve a correct matching of the transistor to the tuned circuit.
As described in Ref. 1. the bandwidth of a tuned circuit remains constant with frequency in the case that the losses in this circuit are caused by a series resistance r_s.
The damping of such tuned circuit decreases with frequency and follows a square law.

The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of: N.V. Philips' Gloeilampenfabrieken - Eindhoven - The Netherlands Product Division Electronic Components and Materials.

Electronic components and materials

Information presented in this report is based on pilot studies in our laboratories. It is presented in good faith but N.V. Philips' Gloeilampenfabrieken assumes no liability for any consequences of its use. Its presentation does not imply a licence under any patent, trademark or copyright.

PHILIPS



$$G_p = \frac{r_s}{\omega^2 L_p^2} \qquad B = \frac{r_s}{2\pi L_p^2}$$

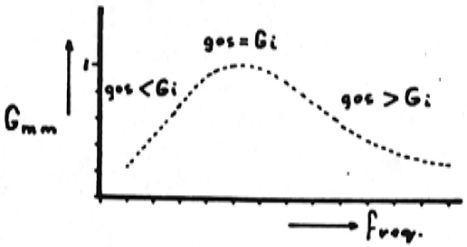
On the other hand, the output damping of the MOST at UHF increases with frequency but follows also a square law. This because of the fact that the output damping "gos" is caused by the drain capacitance Cd and the series resistance of the bulk r_d (see fig. 13).

$Gos \approx r_d \cdot \omega^2 . Cd^2$.

As follows from the formula for the mismatch losses:

$$G_{mm} = \frac{4 . gos . G_i}{(gos + G_i)^2}$$

a direct coupling of the MOST in parallel to the tuned circuit results into an unacceptable frequency dependence of the mismatch losses. (this problem also holds for a bipolar transistor).



In the formula gos represents the output damping of the MOST and Gi the input damping of the bandpass-filter.

$$G_i = (G_p + gos)(1 + q_L^2) - gos$$

In case of a direct coupling, also the bandwidth will strongly increase with frequency because then the gos almost determines the quality factor of the tuned circuit. $B \approx (2\pi)^3 . f_o^4 . L . C_D^2 . r_D$

The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of: N.V. Philips' Gloeilampenfabrieken - Eindhoven - The Netherlands Product Division Electronic Components and Materials.

Electronic components and materials

Information presented in this report is based on pilot studies in our laboratories. It is presented in good faith but N.V. Philips' Gloeilampenfabrieken assumes no liability for any consequences of its use. Its presentation does not imply a licence under any patent, trademark or copyright.

PHILIPS

To avoid these disadvantages the transistor has been coupled via a matching network to the primary of the bandpass filter as shown in Fig. 3.

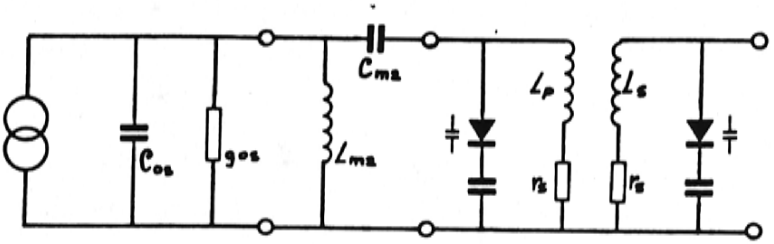


Fig.3

At the highest tuning frequencies the matching network acts like a capacitive tapping "t".

$$t = \frac{C_{m_2}}{C_{m_2} + C_{os}}$$

At lower frequencies these capacitances are partly tuned out by the inductance of Lm_2, which increases the tap on the primary. The resonance frequency fo_2 of the matching network is about 400MHz.

$$f_{o_2} = \frac{1}{2\pi}\sqrt{\frac{1}{L_{m_2}(C_{os} + C_{m_2})}}$$

In this way at increasing frequencies the increasing output damping of the MOST is compensated by a decreasing tapping on the tuned circuit.

To achieve a frequency independence of the bandwidth and transducer gain it is also necessary to keep the relative coupling factor K.Q. of the bandpass filter constant with frequency. Therefore the increasing $Q=(\omega \cdot L/rs)$ has to be compensated by a decreasing coupling factor K.

This is also described in Ref. 1.

The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of: N.V. Philips' Gloeilampenfabrieken - Eindhoven - The Netherlands Product Division Electronic Components and Materials.

Electronic components and materials

Information presented in this report is based on pilot studies in our laboratories. It is presented in good faith but N.V. Philips' Gloeilampenfabrieken assumes no liability for any consequences of its use. Its presentation does not imply a licence under any patent, trademark or copyright.

PHILIPS

The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of N.V. Philips' Gloeilampenfabrieken - Eindhoven - The Netherlands Product Division Electronic Components and Materials

3. THE INPUT CIRCUIT OF THE RF STAGE.

3.1. Parallel matching network

The input damping of a MOST is mainly caused by the gate capacitance Cg together with the channel resistance r_{ch} to the source (see Fig. 13). This circuit delivers an input damping which also follows a square course and increases with frequency. As drawn in Fig. 4 a matching network (C'_{m1}, L'_{m1}), similar to that in the drain, is also necessary on the gate of the MOST.

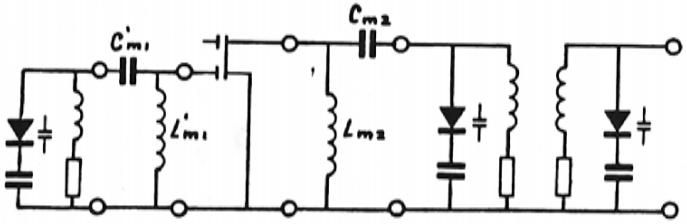


Fig.4

However, this circuit has the following disadvantages:

1. The resonance frequency of the matching network on the gate is almost equal to the resonance frequency of the matching network on the drain thus:

$$f_{o1} = \frac{1}{2\pi}\sqrt{\frac{1}{L'_{m1}(C'_{m1}+C_{is})}} \approx f_{o2} = \frac{1}{2\pi}\sqrt{\frac{1}{L_{m2}(C_{m2}+C_{os})}}$$

This implies a parasitical bandpass at about 400MHz. It will be clear that an interfering signal at this frequency deteriorates the signal handling of the RF stage. A deterioration of the signal handling can also occur in the mixer stage because in this case the latter is protected against the interfering signal by the selectivity of the secondary of the bandpass filter only.

Information presented in this report is based on pilot studies in our laboratories. It is presented in good faith but N.V. Philips' Gloeilampenfabrieken assumes no liability for any consequences of its use. Its presentation does not imply a licence under any patent, trademark or copyright.

PHILIPS

2. The parasitic tuned circuits at the drain and the gate of the MOST, both tuned at about 400MHz, implies also a great risk for instabilities of the RF stage.
3. The gate of the MOST is almost connected to the top of the resonance circuit. Due to the fact that the gate capacitance Cis is almost twice the ouput capacitance Cos, this coupling method causes a strong reduction of the tuning range of the antenna circuit.

3.2. Series matching network.

An input circuit in which the mentioned disadvantages could be avoided is given in Fig. 5.

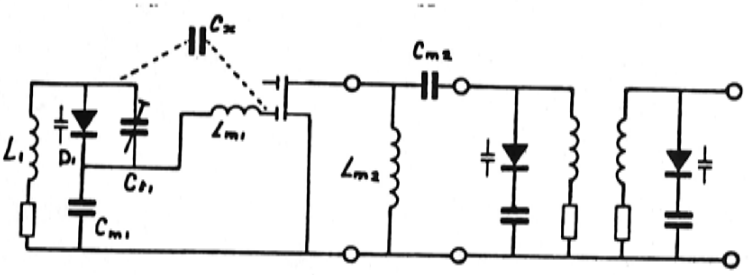


Fig.5

As follows from the figure, the gate has been connected in parallel to the capacitor Cm1 which is the series capacitor of the varicap diode D1.
This results in a variable tapping on the antenna tuned circuit and can be written as:

$$t = \frac{C_{D1} + C_{t1}}{C_{D1} + C_{t1} + C_{m1}}$$

At the high end of the band the coupling of the antenna tuned circuit to the MOST appeared to be to loose, which could be corrected by means of the following measures:

The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of N.V. Philips' Gloeilampenfabrieken - Eindhoven - The Netherlands Product Division Electronic Components and Materials.

Electronic components and materials

Information presented in this report is based on pilot studies in our laboratories. It is presented in good faith but N.V. Philips' Gloeilampenfabrieken assumes no liability for any consequences of its use. Its presentation does not imply a licence under any patent, trademark or copyright.

PHILIPS

1. By the inductance of Lm1 which delivers a series resonance with the input capacitance Cis of the MOST at about 900MHz.
   Due to this, the signal voltage across the input capacitance Cis increases and with that the coupling.
2. The parasitical coupling via C_x appeared to be of much importance because the signal via this coupling acts with an opposite phase with respect to the signal via Lm1. As this mixed coupling decreases rapidly towards higher frequencies, it is very important to minimize the parasitic capacitance "Cx" between the top of the tuned circuit and the gate.
3. The coupling method of Fig. 5 provides only a very small parasitic capacitance in parallel to the tuned circuit. Therefore, to achieve a correct tracking, it is necessary to connect an additional trimming capacitor.
   Usually such capacitor is connected in parallel to the tuning inductance L1. However, in the circuit of Fig. 5 the trimming capacitor Ct1 is connected in parallel to the varicap diode D1. Especially at the high end of the band, this measure results in a higher tapping of the MOST on the antenna tuned circuit.

4. THE TRACKING OF THE RF STAGE.
   An important property of the coupling method of the MOST to the tuned circuits is the fact that the influence of the input capacitance Cis of the MOST on the tuning range is much smaller than the influence of the output capacitance Cos. So in the primary of the bandpass-filter the highest capacitance value (27pF) in series with the varicap diode "BB405B" was needed to cover a frequency range of 470-860MHz together with a tuning voltage of 1-25 Volts. See Fig. 14.

The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of N.V. Philips' Gloeilampenfabrieken - Eindhoven - The Netherlands Product Division Electronic Components and Materials

Electronic components and materials

Information presented in this report is based on pilot studies in our laboratories. It is presented in good faith but N.V. Philips' Gloeilampenfabricken assumes no liability for any consequences of its use. Its presentation does not imply a licence under any patent, trademark or copyright.

PHILIPS

In the secondary of the bandpass-filter a lower capacitance of 18pF satisfies this requirement.
To achieve the right frequency range of the antenna tuned circuit, a capacitor of 15pF appeared to be sufficient, because here this capacitor is shunted by the input capacitance of the MOST (Cis ≈ 2.6pF).
The RF stage was trimmed at the low end of the band by bending the tuninginductances Lt 1, 2 and 3.
At the high end of the band the trimming capacitors Ct 1 and 2 are used. (See Figs. 14 and 15)
The best result can be obtained when the trimming procedure is carried out at about 550 and 800MHz, thus not at the ends of the frequency range.

5. MEASURES FOR DESIGNING A STABLE RF STAGE.

5.1. Simplified equivalent circuit of a MOST tetrode.

As can be seen from Fig. 6 a MOST tetrode is built up by two triodes which are connected in a cascode configuration.

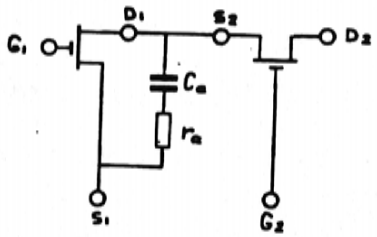


Fig. 6

The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of N.V. Philips' Gloeilampenfabrieken - Eindhoven - The Netherlands
Product Division Electronic Components and Materials

Electronic components and materials

Semiconductor application laboratory SAL Nijmegen - The Netherlands

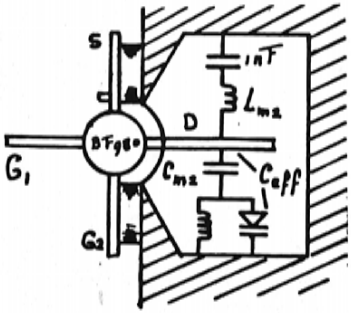
Information presented in this report is based on pilot studies in our laboratories. It is presented in good faith but N.V. Philips' Gloeilampenfabrieken assumes no liability for any consequences of its use. Its presentation does not imply a licence under any patent, trademark or copyright.

PHILIPS

The area between the two channels, which is in fact the interconnection of drain D1 to source S2 delivers a parasitic capacitance Ca and a series resistance r_a with respect to the source S_1 (see also Fig. 13).
Especially this series circuit appears to be responsible for the UHF instabilities of the RF stage, because in the circuit it acts as a feedback for the output triode D2, G2 S2.

5.2. The influence of the print lay-out on the stability.

In Fig. 15 the lay-out of the RF stage is given.
When in this figure the transistor is turned around his gate 1 - drain axis, thus the gate 2 and source connection are exchanged, instabilities at about 400MHz can occur.
This situation is schematically given in Fig. 7a in which the feedback is caused by the inevitable inductance between the decoupling of gate 2 and the source (L print).
The effective tuning capacitance Ceff is caused by the coupling capacitance Cm2 in series with some inductance delivered by the tuned circuit of the primary of the bandpass filter. Note that this circuit is tuned at a higher frequency. In the Fig. 7b and 7c clearly the paracitic oscillator circuit is demonstrated.



L_{print} = parasitic inductance between gate 2 and source decoupling

Fig.7a

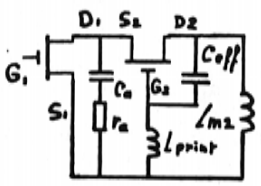


Fig.7b

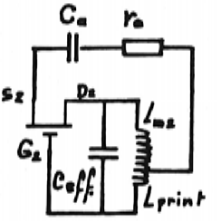


Fig.7c

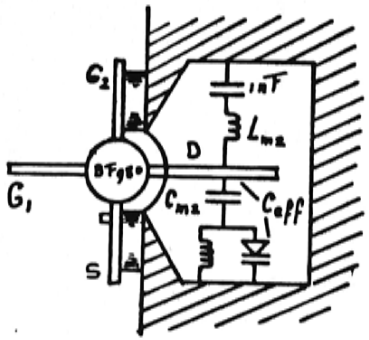
The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of N.V. Philips' Gloeilampenfabrieken - Eindhoven - The Netherlands Product Division Electronic Components and Materials.

Electronic components and materials

Information presented in this report is based on pilot studies in our laboratories. It is presented in good faith but N.V. Philips' Gloeilampenfabrieken assumes no liability for any consequences of its use. Its presentation does not imply a licence under any patent, trademark or copyright.

PHILIPS

When the decoupling of gate 2 and the source are situated as given in Fig. 15, the phase of the feedback actually turns 180 degrees, which provides a stable circuit.
This is demonstrated in the Fig. 8a and 8b.



L_{print} = parasitic inductance between gate 2 and source decoupling.

Fig.8a

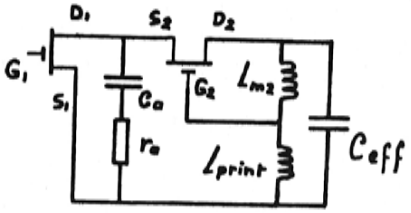


Fig.8b

To give an impression of the working of such a parasitic circuit, in Fig. 16 the simplified circuit diagram around the output triode of the MOST and the corresponding vector diagram is given.
In the vector diagram first the effective gate current ig is drawn, from which the input voltage Vi can be determined.
The voltage across the effective gate capacitance VC_G is responsible for the current source $-i_D = yfs_o.VC_G$.
So this current can be drawn in phase with VC_G.
(yfs_o is measured at a very low frequency).
The source current i_S can be found by adding $yfs_o.VC_G$ to i_G. This current flows through the feedback branch Ca-r_a and causes there a voltage drop "V feedback".
The voltage at the tapping on the tuned circuit can be found by the addition : Vfeedback + Vi = V_D tap.

The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of: N.V. Philips' Gloeilampenfabrieken - Eindhoven - The Netherlands Product Division Electronic Components and Materials.

Electronic components and materials

Information presented in this report is based on pilot studies in our laboratories. It is presented in good faith but N.V. Philips' Gloeilampenfabrieken assumes no liability for any consequences of its use. Its presentation does not imply a licence under any patent, trademark or copyright.

PHILIPS

In the vector diagram the drain voltages caused by the drain current i_D across the tuned circuit as a function of the relative detuning β are given by the circle:

$$V_{D'} = -i_D \frac{R_p}{1+j\beta Q}$$

At the tapping on the tuned circuit this voltage only depends on the tap ratio t and can be written as:

$$V_{D'tap} = V_{D'} \cdot t$$

When the vector V_{Dtap} is situated inside the circle $V_{D'tap}$ the loop gain is >1 which results in an unstable RF stage.

In the circuit of Fig. 8 the vector V_{Dtap} has been shifted 180 degrees, thus outside the circle $V_{D'tap}$ which provides a stable RF stage.

5.3. Instability due to the inductance in the decoupling connection of gate 2.

Another cause of parasitic oscillations in VHF and in UHF stages as well, are the lead-inductances in the decoupling of gate 2 and the source.

These inductances deliver together with the drain-gate 2 capacitance (C_{D2}-G_2) and the bulk-island capacitance of the MOST (Ca), a parasitic oscillator circuit at UHF frequencies.

As drawn in Figs. 9a to 9c, even a complete oscillator circuit is possible, only by the presence of some lead inductance in the decoupling of gate 2 (L_{G2}).

In this particular case, an effective decoupling of the drain and source has been assumed.

The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of N.V. Philips' Gloeilampenfabrieken - Eindhoven - The Netherlands
Product Division Electronic Components and Materials.

Electronic components and materials

Information presented in this report is based on pilot studies in our laboratories. It is presented in good faith but N.V. Philips' Gloeilampenfabrieken assumes no liability for any consequences of its use. Its presentation does not imply a licence under any patent, trademark or copyright.

PHILIPS

The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of N.V. Philips' Gloeilampenfabrieken - Eindhoven - The Netherlands
Product Division Electronic Components and Materials.

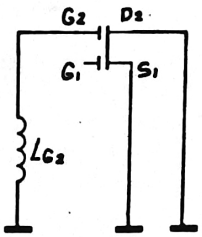


Fig.9a

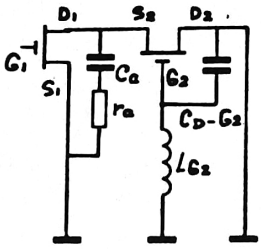


Fig.9b

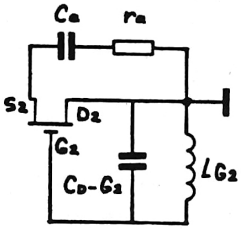


Fig.9c

In practice such effective decoupling cannot be realized due to the residual lead inductances.
This knowledge results into the circuit diagram of Figs. 10a to 10c.

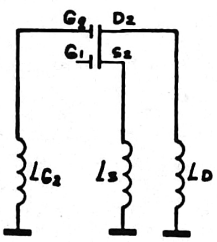


Fig.10a

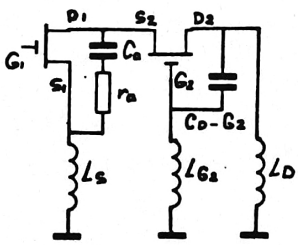


Fig.10b

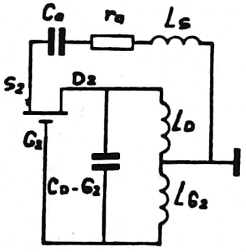


Fig.10c

Electronic components and materials

Semiconductor application laboratory SAL Nijmegen - The Netherlands

Information presented in this report is based on pilot studies in our laboratories. It is presented in good faith but N.V. Philips' Gloeilampenfabrieken assumes no liability for any consequences of its use. Its presentation does not imply a licence under any patent, trademark or copyright.

PHILIPS

From these Figs. it appears that the inductance in the drain "L_D" influences the circuit in two manners.
Firstly by decreasing the oscillation frequency, which decreases the modulus of the feedback "Ca eff.".
Secondly it introduces a tapping of the feedback-branch on the tuned circuit.

$$t = \frac{L_{G2}}{L_D + L_{G2}}$$

So in some particular cases it will be possible to avoid parasitic oscillations, simply by increasing the lead inductance in the drain.
Regarding the influence of the parasitic inductance in the source, "Ls", it can be concluded that this inductance increases the effective feedback capacitance "Ca eff.".

$$C_{a\,eff} = \frac{C_a}{1 - \omega^2 . L_s . C_a}$$

It will be clear that for a stable circuit this inductance has to be minimized.
The vector diagram given in Fig. 16 also applies to this parasitical oscillator circuit.
In feedback-branch, however, one has to exchange "Ca" by "Ca eff.".

6. PRACTICAL LAY OUT OF THE PRINTED BOARD.

The circuit diagram of the complete RF stage and the practical lay-out is given in the Figs. 14 and 15.
To prevent a deterioration of the gain control range and the stability of the RF stage as well, a minimum parasitical coupling from the output to the input of the RF stage is necessary.
Therefore the following measures have been taken:
A parasitic coupling from the antenna tuned circuit to the tuned circuits of the bandpass filter can be caused by uncontrolled RF currents in the printed board.

The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of N.V. Philips' Gloeilampenfabrieken - Eindhoven - The Netherlands Product Division Electronic Components and Materials

Electronic components and materials

Information presented in this report is based on pilot studies in our laboratories. It is presented in good faith but N.V. Philips' Gloeilampenfabrieken assumes no liability for any consequences of its use. Its presentation does not imply a licence under any patent, trademark or copyright.

PHILIPS

To concentrate these currents around the tuned circuits, the earth connections of the varicapdiodes and tuning inductances are situated as near as possible to each other. For the same reason the tuned circuits are enclosed by the copperfoil of the printed board. A coupling can also be caused by some parasitic feedback capacitance. This demands for a screening which separates the input from the output of the RF stage. This screen also enables minimum lead inductances in the source and gate2 decoupling.As described in section 3.2 the parasitic capacitance between the top of the antenna tuned circuit and gate 1 has to be kept as small as possible. So, in the print lay-out there is a great distance between these areas.
Also the positioning of the rectángular ceramic capacitor Cm1 delivers some screening.

6.1. The coupling of the bandpass filter.

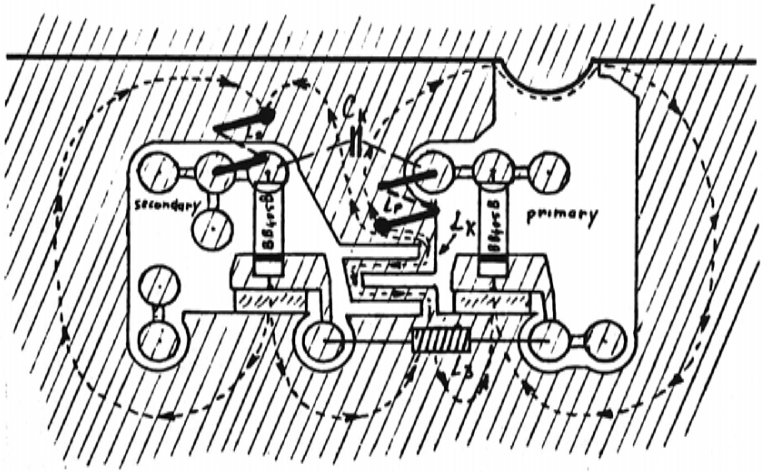


Fig.11

As shown in Fig. 11 the bandpass filter has been coupled in four ways:

The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of N.V. Philips' Gloeilampenfabrieken - Eindhoven - The Netherlands Product Division Electronic Components and Materials.

Electronic components and materials

Information presented in this report is based on pilot studies in our laboratories. It is presented in good faith but N.V. Philips' Gloeilampenfabrieken assumes no liability for any consequences of its use. Its presentation does not imply a licence under any patent, trademark or copyright.

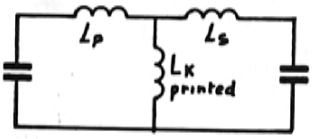
PHILIPS

1. A inductive T coupling by means of the common inductance L_k.
2. A inductive π coupling via L_3, which acts via a variable tapping on the tuned circuits.
3. A indirect inductive coupling.
4. A capacitive π coupling via the capacitance C_K between the circuits.

In order to minimize the dimensions of the bandpass filter, the coupling methods 1 and 2 are partly compensated bij the coupling methods 3 and 4.
This is necessary because no shield between the primary and secondary is applied, which, as a matter of course should result into a to high coupling factor.
To achieve a negative indirect inductive coupling, the coils have been connected in opposite directions.
The advantage of this method is that these coils have equal directions of windings.

6.2. Design methods for a positive coupling.

6.2.1. The inductive T coupling via Lk.



$$K = \frac{L_K}{\sqrt{(L_K + L_P)(L_K + L_S)}}$$

In case Lp≈Ls=L the formula can be simplified to:

$$K = \frac{L_K}{L_K + L}$$

This coupling method is frequency independent.

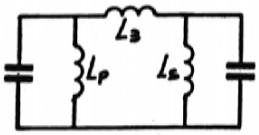
The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of N.V. Philips' Gloeilampenfabrieken - Eindhoven - The Netherlands Product Division Electronic Components and Materials.

Electronic components and materials

Information presented in this report is based on pilot studies in our laboratories. It is presented in good faith but N.V. Philips' Gloeilampenfabrieken assumes no liability for any consequences of its use. Its presentation does not imply a licence under any patent, trademark or copyright.

PHILIPS

6.2.2. The inductive π coupling via L3.

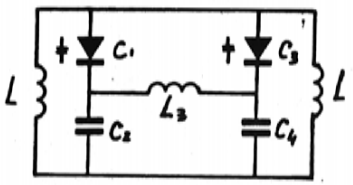


$$K = \sqrt{\frac{L_p \cdot L_s}{(L_3 + L_p)(L_3 + L_s)}}$$

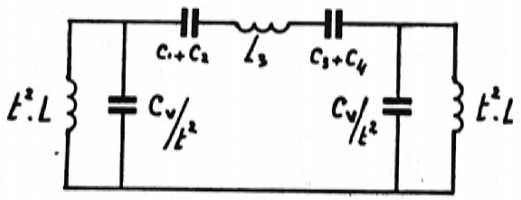
In case $L_p \approx L_s = L$ the formula can be simplified to:

$$K = \frac{L}{L_3 + L}$$

As shown in the figure below, in the circuit the coupling coil L_3 is connected on a capacitive tapping.



The equivalent circuit diagram is also given.



In this figure it is assumed that C1 $\approx$ C3 and C2 $\approx$ C4 thus

$$t = \frac{C_1}{C_1 + C_2} \approx \frac{C_3}{C_3 + C_4}$$

in general the reactance of C1 + C2 and C3 + C4 is negligible small versus the reactance of L3.

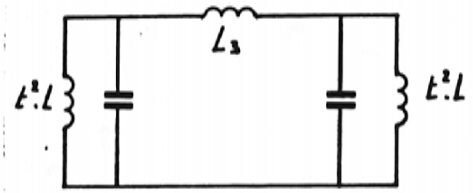
The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of: N.V. Philips' Gloeilampenfabrieken - Eindhoven - The Netherlands Product Division Electronic Components and Materials.

Electronic components and materials

Information presented in this report is based on pilot studies in our laboratories. It is presented in good faith but N.V. Philips' Gloeilampenfabrieken assumes no liability for any consequences of its use. Its presentation does not imply a licence under any patent, trademark or copyright.

PHILIPS

So the figure can be simplified further to:



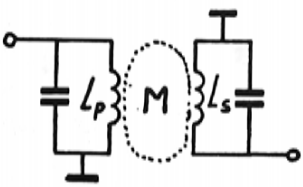
From this figure the expression for K becomes:

$$K = \frac{L}{L_s/t^2 + L}$$

In the formula, t decreases with frequency and consequently the coupling K.

6.3. Design methods for a negative coupling.

6.3.1. The indirect inductive coupling.



This coupling acts with an apposite sign due to the reversed connections of the coils Lp and Ls

$$-K = \frac{M}{\sqrt{L_p . L_s}}$$

in case $Lp \approx Ls = L$ for - K can be written:

$$-K = M/L$$

This coupling is frequency independent.

6.3.2. The capacitive π coupling.

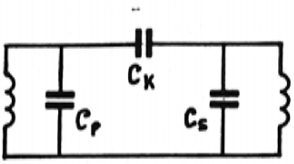
With respect to the inductive π and T coupling this coupling acts also with an opposite sign.

The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of N.V. Philips' Gloeilampenfabrieken - Eindhoven - The Netherlands
Product Division Electronic Components and Materials

Electronic components and materials

Information presented in this report is based on pilot studies in our laboratories. It is presented in good faith but N.V. Philips' Gloeilampenfabrieken assumes no liability for any consequences of its use. Its presentation does not imply a licence under any patent, trademark or copyright.

PHILIPS



$$-K = \frac{C_K}{\sqrt{(C_K + C_p)(C_K + C_s)}}$$

in case $Cp \approx C_s \approx C$

then for $-K$ can be written:

$$-K = \frac{C_K}{C_K + C}$$

With frequency, the tuning capacitance C decreases, which results into an increasing coupling.

In Fig.12 the frequency dependence of each coupling and the resulting mixed coupling has been sketched.

This mixed coupling decreases with frequency, which delivers together with the increasing Q of the tuned circuits a frequency independent relative coupling factor K.Q.

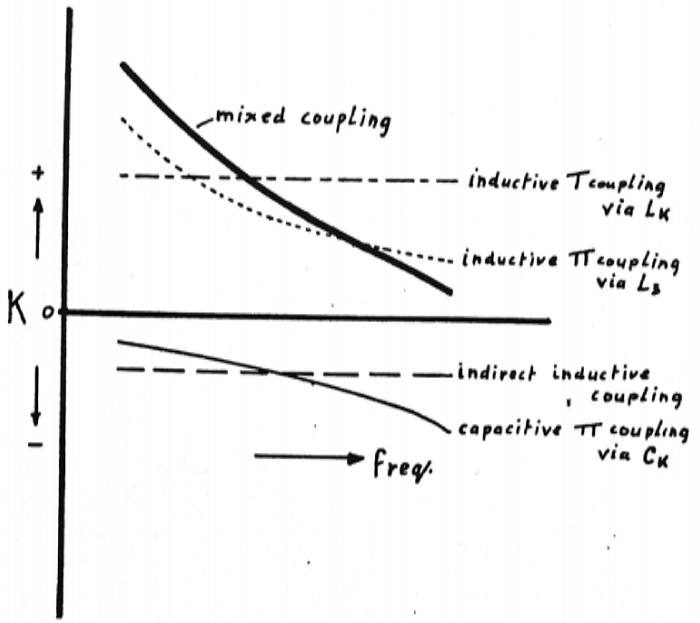


Fig.12

The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of N.V. Philips' Gloeilampenfabrieken - Eindhoven - The Netherlands
Product Division Electronic Components and Materials.

Electronic components and materials

Information presented in this report is based on pilot studies in our laboratories. It is presented in good faith but N.V. Philips' Gloeilampenfabrieken assumes no liability for any consequences of its use. Its presentation does not imply a licence under any patent, trademark or copyright.

PHILIPS

7. Measurements.

In the table some results of the RF stage equipped with a BF 980 are given.
More information about the DC biasing, signal handling, agc characteristics etc. is given in reference 2.

Measured results

Freq. (MHz)	Tuning voltage (Volts)	Noise fig. (dB)	Transd. gain (dB)	Gain reduct. (dB)	3dB band width (MHz)	VSWR (m.b) at nom gain	VSWR (m.b) at max. gain red
470	1.7	3.3	13.8	48	24	1.8	2.8
600	7.7	3.5	11	40	23	1.4	2.6
730	13.5	3.9	10.2	41	24	1.4	2.4
860	25.1	4.2	10	44	19	1.4	3.1

8. Conclusion:

It is shown that the RF stage equipped with a BF 980 provides excellent UHF performance.
A good solution has been found for the coupling of the MOST tetrode to the antenna tuned circuit, in which an additional coupling varicap could be avoided.
The bandpass filter is simplified by the application of ordinary wire wound coils in the tuned circuits.
This provides a cheaper RF stage and a good relectivity as well.
Some design rules, providing a stable RF stage are also given.

The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of: N.V. Philips' Gloeilampenfabrieken - Eindhoven - The Netherlands Product Division Electronic Components and Materials.

Information presented in this report is based on pilot studies in our laboratories. It is presented in good faith but N.V. Philips' Gloeilampenfabrieken assumes no liability for any consequences of its use. Its presentation does not imply a licence under any patent, trademark or copyright.

PHILIPS

9. References.

1. "Some principles for the design of a UHF RF stage".
By: R.C. Thuis, report nr. NTI 7406

2. "Application of the MOST tetrode BF980 in a UHF RF stage".
By: H. Th Uittenbogaard, report nr. NTI 8202.

The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of: N.V. Philips' Gloeilampenfabrieken - Eindhoven - The Netherlands Product Division Electronic Components and Materials.

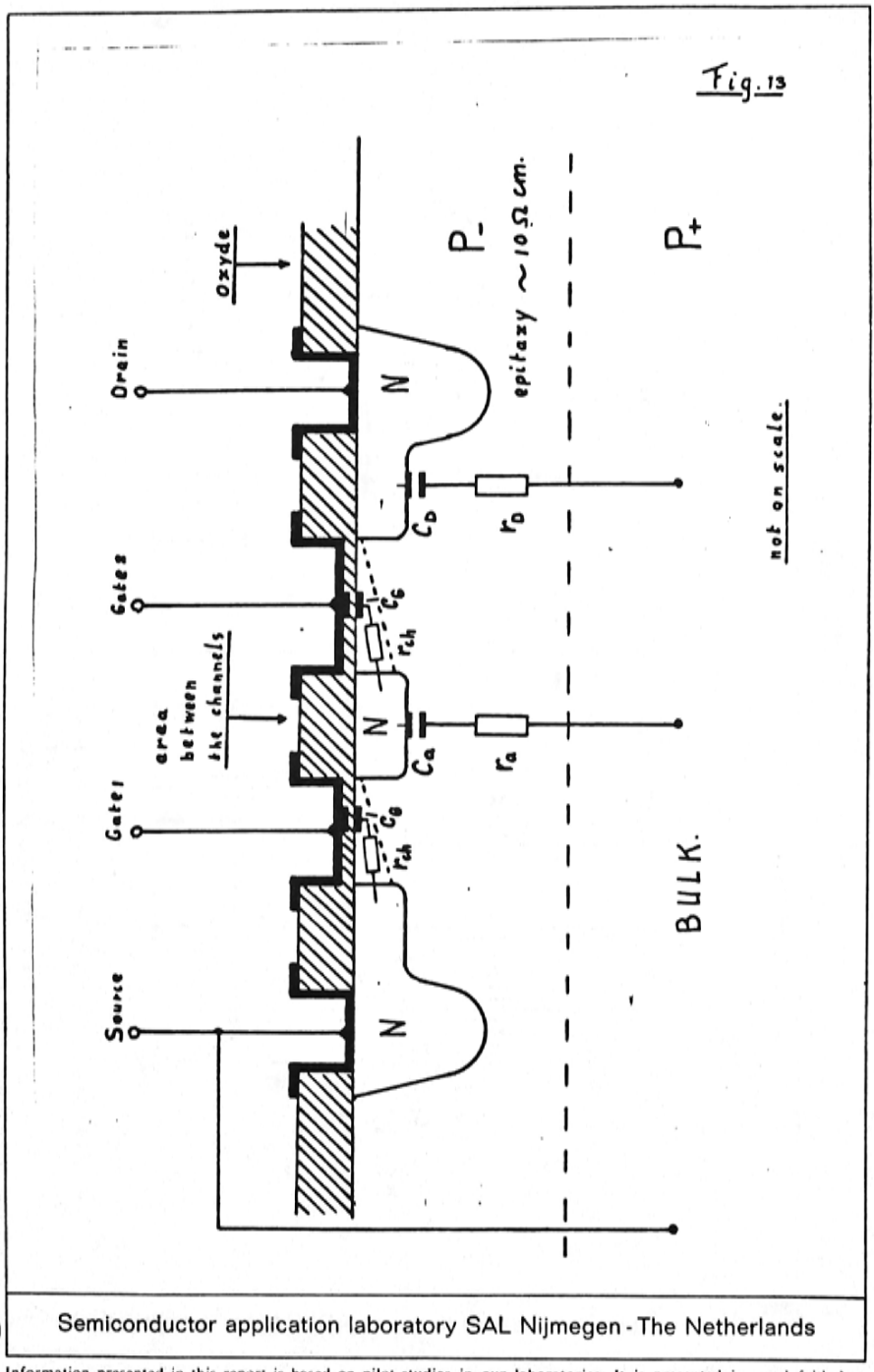
Electronic components and materials

Information presented in this report is based on pilot studies in our laboratories. It is presented in good faith but N.V. Philips' Gloeilampenfabrieken assumes no liability for any consequences of its use. Its presentation does not imply a licence under any patent, trademark or copyright.

PHILIPS

The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of N.V. Philips' Gloeilampenfabrieken - Eindhoven - The Netherlands Product Division Electronic Components and Materials.

Electronic components and materials



Semiconductor application laboratory SAL Nijmegen - The Netherlands

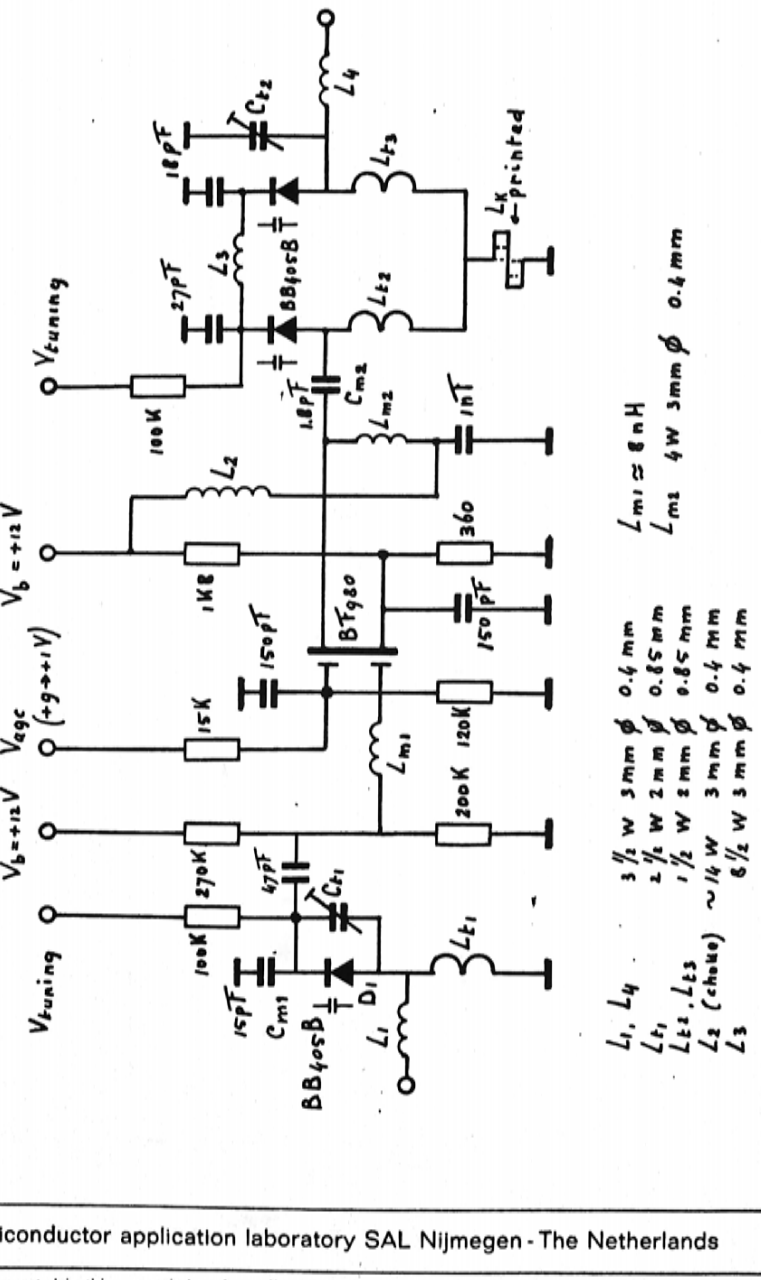
Information presented in this report is based on pilot studies in our laboratories. It is presented in good faith but N.V. Philips' Gloeilampenfabrieken assumes no liability for any consequences of its use. Its presentation does not imply a licence under any patent, trademark or copyright.

PHILIPS

The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of: N.V. Philips' Gloeilampenfabrieken - Eindhoven - The Netherlands. Product Division Electronic Components and Materials.

Electronic components and materials

Fig. 14

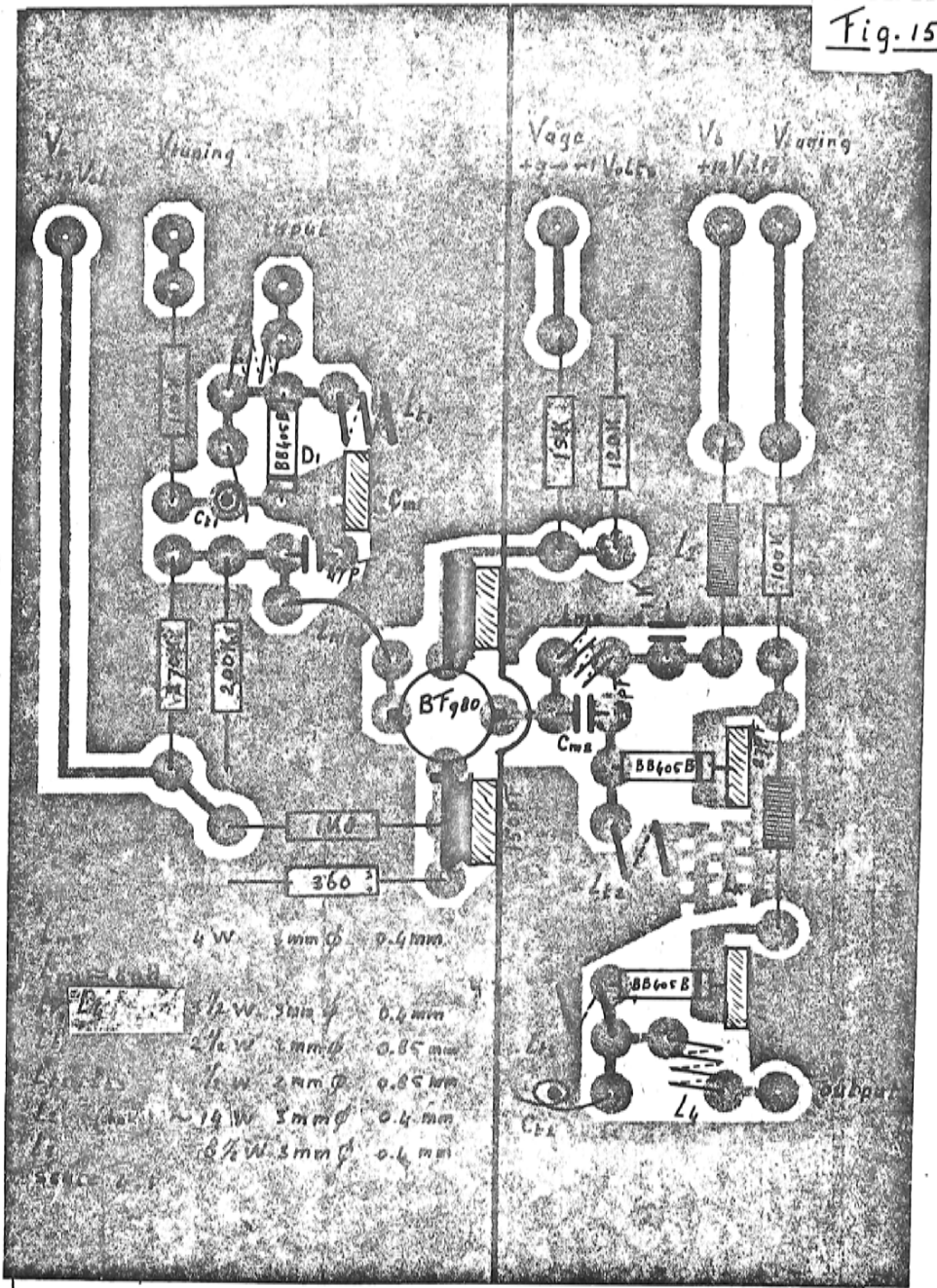


Semiconductor application laboratory SAL Nijmegen - The Netherlands

Information presented in this report is based on pilot studies in our laboratories. It is presented in good faith but N.V. Philips' Gloeilampenfabrieken assumes no liability for any consequences of its use. Its presentation does not imply a licence under any patent, trademark or copyright.

PHILIPS

Fig. 15



The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of N.V. Philips' Gloeilampenfabrieken - Eindhoven - The Netherlands
Product Division Electronic Components and Materials

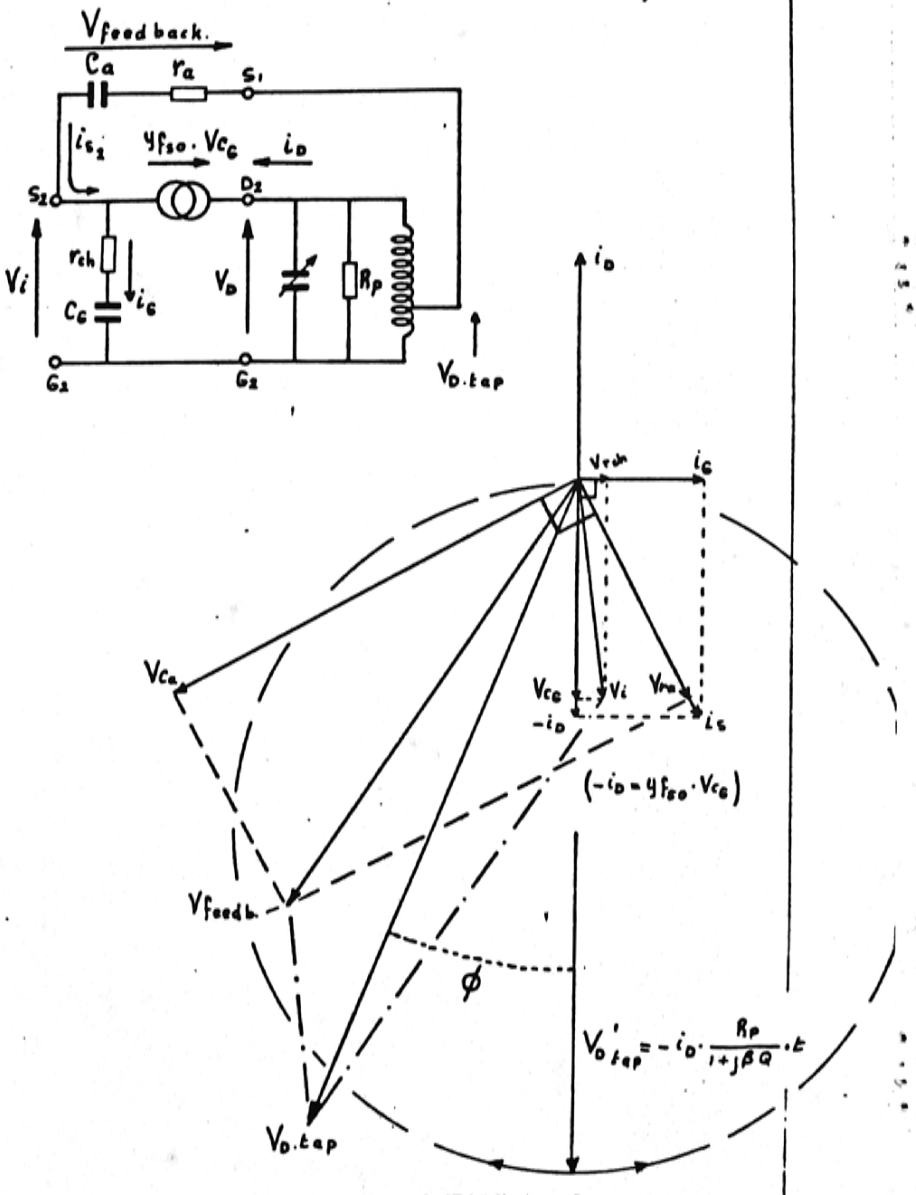
Electronic components and materials

Semiconductor application laboratory SAL Nijmegen - The Netherlands

Information presented in this report is based on pilot studies in our laboratories. It is presented in good faith but N.V. Philips' Gloeilampenfabrieken assumes no liability for any consequences of its use. Its presentation does not imply a licence under any patent, trademark or copyright.

PHILIPS

Fig. 16



The contents of this report are not to be reproduced, in whole or in part, nor disclosed to third parties without the written consent of N.V. Philips' Gloeilampenfabrieken - Eindhoven - The Netherlands Product Division Electronic Components and Materials

Electronic components and materials

Semiconductor application laboratory SAL Nijmegen - The Netherlands

Information presented in this report is based on pilot studies in our laboratories. It is presented in good faith but N.V. Philips' Gloeilampenfabrieken assumes no liability for any consequences of its use. Its presentation does not imply a licence under any patent, trademark or copyright.